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Blue Stain in Engelmann Spruce Trap Trees Treated with Cacodylic Acid

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One year after treatment, stain had penetrated the sapwood of untreated trees but was negligible in treated trees. Time of treatment had no effect upon the amount of stain in treatments acceptable for beetle control. The treatment that gave the best lethal effect on bark beetles also resulted in the least amount of blue stain. Incipient decay was present in the stained sapwood 1 year after treatment.

KEY WORDS: *Picea engelmannii, Leptographium engelmannii, Ceratocystis coerulescens, C. olivacea.*

The spruce beetle, Dendroctonus rufipennis (Kirby), is the most serious pest of Engelmann spruce (Picea engelmannii Parry) forests in the United States. Because adult beetles prefer windfalls and other downed material to live standing trees, live trees can be felled and used as traps to attract the beetles. The trap tree method (Nagel et al. 1957) is an accepted management practice in the suppression of this pest.

The injection of the herbicide cacodylic acid (diamethylarsenic acid) into living spruce recently has been shown to be a practical method for producing trap trees lethal to the spruce beetle (Buffam 1971, Buffam and Yasinski 1971, Frye and Wygant 1971). The infested trap trees need not be logged, burned, or treated with chemicals to kill the resultant brood. The trap trees can be safely harvested any time after the flight period of the beetle, or left in the woods.

With an extended period of time available for harvesting lethal trap trees, the question arises concerning the deterioration of these trees. A study of the deterioration of beetle-killed spruce in Colorado (Hinds et al. 1965) revealed that trees on the ground begin to decay rapidly, and that the average amount of decay varied from 16-19 percent within 5 years, depending upon the proportion of the tree in contact with the ground. The sapwood of infested Engelmann spruce is soon invaded by blue stain fungi carried by the spruce beetle, and the entire sapwood is normally colonized within 1 or 2 years.

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Frye and Wygant (1971) observed that blue stain was suppressed in trap trees treated with cacodylic acid and felled. This study was made to determine the effect of cacodylic acid upon decay and blue stain development in Engelmann spruce trap trees. It was made in conjunction with a study by Buffam (1971) to determine the best methods of producing lethal trap trees.

Methods

Two study areas were chosen in May 1969, adjacent to a spruce beetle-infested stand on the Santa Fe National Forest, south of Coyote, New Mexico. Four treatment blocks were designated in each area. In each block, 21 mature spruce trees were numbered for identification. The following treatments were made to three trees in each of the eight blocks:[3]

1. Frilled and treated with full-strength Silvisar 510 and left standing.
2. Frilled and treated with full strength Silvisar 510 and felled.
3. Frilled and treated with half-strength Silvisar 510 and left standing.
4. Frilled and treated with half-strength Silvisar 510 and felled.
5. Frilled only and left standing (control).
6. Frilled only and felled (control).
7. Felled without frilling or treating (control).

All frills penetrated the sapwood and were chopped with a hatchet. Silvisar 510 was applied to the frills with a plastic squeeze bottle. Full-strength Silvisar 510 was diluted with an equal quantity of tap water for the half-strength treatments. About 1 ml of solution was applied per inch of tree circumference.

The four blocks in each area were treated at different times. These times—based on July 15 as peak beetle flight—were:

A. Frilled and treated 8 weeks before peak beetle flight (May 21) and felled 4 weeks before peak flight (June 17).
B. Frilled and treated 8 weeks before peak beetle flight (May 21) and felled 2 weeks before peak flight (June 30).
C. Frilled and treated 4 weeks before peak beetle flight (June 16) and felled 2 weeks before peak flight (June 30).
D. Frilled and treated 4 weeks before peak beetle flight (June 16) and felled later the same week (June 18).

Treatments were assigned at random. In total, 168 trees—24 within each of seven treatment categories—were involved in the test. The trees averaged from 15 to 17 inches d.b.h., 80 to 90 feet in height, and were 100 to 207 years old (Buffam 1971). Volume of the six trees in each treatment-time combination ranged from 320-510 cubic feet.

The results were evaluated during the period June 9-24, 1970. Trees left standing in 1969 were felled, and all test trees were limbed and bucked into log lengths of 8 to 24 feet to a 6-inch top. Logs and blue stain were measured so that cubic-foot volumes could be computed by use of Smalian's formula. Where blue stain did not extend throughout the length of a log, additional cuts were made to determine its length. At least one sample of blue stain was taken from each tree for isolation of fungi.

Results

There were no significant differences between similar treatments in the two areas, so data from both areas were combined for analysis. The data (table 1) were analyzed as a factorial experiment to determine the main effects and interactions between treatment and treatment times on blue stain. Three main conclusions emerged from the analysis:

1. Treatment time had no effect on blue stain with the exception of treatment D.
2. The effect of acid strength was different for standing trees (which sustained few beetle attacks and negligible amounts of blue stain) and down trees (in which blue stain decreased with increased dosage).
3. There was no interaction between treatment time and dosage.

A total of 256 isolations were made from stained sapwood: 224 from blue stain and 32 from brown stain associated with ambrosia beetle galleries. More than one fungus was commonly isolated from a specimen. *Leptographium engelmannii* Davidson was the most common blue stain fungus; it was isolated from 95 percent of the blue stain samples. In addition to *L. engelmanni*, *Ceratocystis olivacea* (Mathiesen) Hunt was isolated from blue stain in 12 trees and *C. coerulescens* (Münch) Bakshi from seven trees. The fungus most consistently associated with the small pockets of brown stain around the ambrosia beetle galleries was *C. coerulescens*; it was isolated from 80 percent of the brown stain samples.

[3] *Trade names are used for the benefit of the reader and do not imply endorsement by the U. S. Department of Agriculture. Silvisar 510 (manufactured by the Ansul Company) contains the equivalent of 6.0 lb. of cacodylic acid/gal. Silvisar 510 Tree Killer has been approved by the Pesticides Regulation Division of the Environmental Protection Agency (February 24, 1971) for use in bark beetle control by professional foresters in the Rocky Mountains of South Dakota, Colorado, Arizona, and New Mexico.*

Table 1.--Percent blue stain volume by treatment and treatment time (1969) in Engelmann spruce trap trees. Each figure is an average of six trees.

No.	Treatment Description	Treated May 21[1] Felled June 17 (A)	Treated May 21[1] Felled June 30 (B)	Treated June 16[1] Felled June 30 (C)	Treated June 16[1] Felled June 18 (D)
1.	Frill, acid full strength, standing	0.6	2.7	2.5	2.6
2.	Frill, acid full strength, felled	2.3	5.0	1.6	11.2
3.	Frill, acid half strength, standing	1.5	3.5	3.1	3.5
4.	Frill, acid half strength, felled	5.1	4.7	2.9	20.9
5.	Frill, no acid, standing[2]	0.0	0.0	0.2	0.3
6.	Frill, no acid, felled	28.5	27.7	36.8	28.1
7.	Felled only	17.2	33.0	24.0	28.1

[1]Note that treatments 1, 3, and 5 did not involve felling.
[2]Trees in this treatment attracted very few beetles and were still alive in 1970.

L. engelmanni was also isolated five times. An unidentified species of Ceratocystis and three Graphium spp. were also isolated from stain.

Advance sap rot was not evident in any of the trap trees. Although the felled trees had been on the ground approximately 1 year, the only evidence of sap rot fungi was from the isolations. Fomes pinicola (Swartz) Cke. was isolated 24 times from stain samples from felled trees. Two other unidentified sap rot organisms were isolated from eight samples. The isolations indicated that incipient decay was present in the down trees, and that early removal of trap trees is necessary to obtain maximum lumber values.

Discussion

Frye and Wygant's (1971) observations that blue stain was inhibited in Engelmann spruce trap trees treated with cacodylic acid was substantiated in this study. Although blue stain is of secondary importance compared to the reduction of beetle populations, less degrade by blue stain would be a plus factor in evaluating the method for producing lethal trap trees.

Treatments 1, 3, and 5, frilled but left standing, were ineffective as trap trees because very few beetles were attracted to them (Buffam 1971). All 24 trees in treatment 5 were still alive 12 and 13 months after being frilled in 1969. Treatments 6 and 7 (no acid, felled) were controls, and should not be considered in an analysis of treatments. While these trap trees readily attracted insects, they would have to be treated or disposed of prior to beetle emergence. Even though differences between full- and half-strength acid in treatments 2 and 4 on blue stain were significant, the small amount of blue stain volume involved may not be worth the added cost of the full-strength treatment. Here the choice of treatment would best be made upon the difference in lethal effect upon the beetles. Since there was no difference in the lethal effect between the two treatments (Buffam 1971), treatment 4 with half-strength acid would be preferable.

Significantly more live brood was found in timing treatment D, probably because time between treatment and felling was not long enough for adequate acid translocation. Otherwise there was no effect between treatment time and amount of blue stain. Late snow cover in the Rocky Mountains would probably eliminate timing treatments A and B.

Buffam (1971) recommended a lethal trap method in which trees are frilled and treated with half-strength Silvisar 510 approximately 4 weeks before peak beetle flight and felled approximately 2 weeks before peak beetle flight (June 16 and June 30, 1969 in this study). This method, treatment 4-C, would also result in only small amounts of blue stain.

Blue stain in trap trees not treated with acid was typical of that found in beetle-killed trees. Stain completely penetrated the sapwood within a year. Stain in acid-treated trees was usually in small streaks 2 to 6 inches wide which extended upward from the butt varying distances, but only in areas where the tree was in contact with the ground. Rarely did the stain encompass the sapwood circumference, and then only in the basal portion of the tree below the frill.

Damage to the sapwood by ambrosia beetles was common in some trees. Ambrosia beetles are important because their galleries penetrate the sapwood and reduce the grade of the lumber cut from the logs. Frye and Wygant (1971) found that acid treatment did not affect construction of egg galleries by Trypodendron lineatum or kill the parent adults, and our limited data confirm this. Beetle damage was heavy in trees in treatments 1 and 3 in which there was little blue stain, whereas damage was negligible in the treatments 6 and 7 where blue stain was more common. It appeared that ambrosia beetles did not attack blue stained sapwood.

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